Low Cost High Frequency Function Generator with Variable Power Supply For Academic Purpose

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***Abstract*—Dual channel function generator with variable power supply is a single module which comprises of dual channel digital function generator, fixed and variable power supply, a DSO138 oscilloscope, breadboard and USB port. This module is specially designed for academic purpose. The dual channel digital function generator generates sine, square, sawtooth and triangular waveforms. Since it is dual channel two different waveforms with different specifications can be generated simultaneously. This reduces the cost and space occupied by two single channel function generators. Variable and fixed power supply generated voltages that is required for the analog circuits in academic laboratory. The DSO138 oscilloscope displays low frequency waveforms on TFT display which is helpful for the user to analyze the output. A breadboard is attached to the module to perform analog experiments.**

Keywords—Microcontroller, Function generator, Power supply.

I. INTRODUCTION

Function generator is the basic instrument for any electronic testing device. Low frequency based function generators are most probably used in academic laboratory. Along with function generators there is a requirement of oscilloscope and variable power supply for conducting analog experiments in academic laboratory. The cost of each device mentioned above is high. It also occupies more space individually. To solve this problem this paper discusses about bringing all three components into one module. This paper proposes a high frequency function generator with dual channel, variable power supply to power any analog components, Oscilloscope to analyse waveforms, breadboard is attached to this module to conduct an experiment. The main purpose of this module it to reduce cost and size. It almost includes all electronic devices into one module. It can be used in all analog electronics lab and communication labs. The low frequency waveforms are used in testing instruments. This integration will bring all analog electronics devices used in analog or digital labs into one device. It also reduces cost and occupies less space.

II. LITERATURE SURVEY

Function generator is existing from 1920. It was used for communications in radar techniques. Earlier it was used for qualitative analysis and it gradually changed to quantitative analysis. Storer and Turyn [1] has generated waveforms using periodic shift-register sequences. These are independently discovered by a number of authors [2]. The first function generator evolved in generating pulse waveforms. The earlier function generators had mechanical structure, which was very complex. The function generator was made using only transistors [3] before 1964. Then later the function generators were designed using active and passive devices which generated only one waveform. The waveforms were of short range, low precision and low durability. Those function generators did not have any processors or memory to generate and save waveforms.

Later it developed into analog function generators. These generators used combination of transistors ie. Operational amplifiers, to generate waveforms. ICs like LM741 and LM8038, was used to generate waveforms. These ICs generated three waveforms like sine, square and triangle. The frequency range was from 6Hz to 7000Hz. These function generators produced more noise.

Later computerized function generator evolved. It used microprocessor to generate waveforms. It generates more than three waveforms as explained in [4-5]. It is of high cost and complex designs. Digital function is a waveform generator which uses microcontroller. It is explained in [6-9]. There are also DDS (Direct digital synthesis) function generator [10] which initially generates waveforms and stores it memory. The memory used is ROM. Whenever the same parameter is requested it displays the waveform from look up table instead of generating it again [11-22]. There are also Arbitrary waveform generators which generates any kind of shapes. The user can generate the desired waveforms. The history of all function generators is explained in [23]

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The main intension of this paper is to design a low cost high frequency function generator which can be used for academic purpose. The concept used in this paper is referred from the paper written by authors Santosh Shanbhag and Ravi Talawar [24-25]. It is explained that the handheld signal generator and oscilloscope is designed. But the maximum frequencies of waveforms are up to 65535Hz. The module proposed in this paper generates waveforms up to 4MHz with dual channel.
The module proposed in this paper has the integration of dual channel digital function generator, variable power supply, oscilloscope, and breadboard. This kit suits for ATL (Atal Tinkering Labs) which are coming up in Schools and for academic purposes in engineering colleges.

III. SYSTEM DISCREPTION

A. Hardware Descriptions

The block diagram is shown in fig1. The system consists of two microcontrollers. ARM 7 microcontroller(LPC2148) is used. The request for the waveform selection is given as an analog input to ADC of Microcontroller [27-30]. With respect to the input the respective loop in a code is executed. The digital output is again converted into analog signal using DAC. The output is fed as an input to DSO138 oscilloscope. The digital storage oscilloscope displays the waveforms on TFT display. The ARM controller contains 60MHz operating frequency. This frequency is used to generate waveforms as per the code. The code spends some to execute the requested waveforms. This paper generates waveforms with maximum of 4MHz frequency. The module generates minimum frequency of 1Hz. The fixed power supply of +12V and -12V are generated using a centre tapped transformer, rectifier, noise removing capacitor and a constant voltage regulator. LM7812 is a voltage regulating IC used to generate +12V and LM7912 is a voltage regulating IC used to generate -12V. +12V and -12V are used as a supply for analog circuits especially operational amplifiers. A variable voltage supply is used to generate variable voltages from 1V to 11.6V. LM317 is a variable voltage regulating IC used to generate voltages from 1V to 11.6V.

B. Software Descriptions

The software used for this model is Keil. The coding is done using embedded C. The code includes LCD.h header file and loops for different waveforms. The flow chart [31] of the code used is given in fig2. It first reads the analog input. As per the input or the channel selection the respective loop is executed with respective frequency [26] on LCD 16X2. As the pot 1 and pot 2 is varied the frequency changes. As the pot3 is varied the amplitude of the signal is varied.

The input for waveform selection is given at P1.0, P1.1, P1.2 and P1.3 of arm controller. The analog input is sensed and the main.c code leads to the respective selected loop. When the loop gets executed the digital values of waveforms are generated. These values are converted into analog by using DAC. The output is taken form DAC pins and the waveform signals are displayed on the DSO138 TFT display.

IV. THEORTICAL ANALYSIS

Digital function generator is designed using various steps. An ADC takes analog input and converts it into digital information. This digital information is compared in the code. For example, square wave is sensed. The loop assigned for square wave is executed. There are constant positive cycles and constant negative cycles in square wave. The wave is maintained constant for a period of frequency requested by user. This constant frequency is obtained by adding delay. As the user varies the frequency the delay time changes as shown in equation (1), thus generates square wave. As it is square wave the delay time for positive cycle and negative cycle is kept same. So that it produces 50% duty cycle.

Similarly, the triangle waves are generated by incrementing the values evenly from 0 to 1024 in positive cycle and by decrementing the values evenly from 1024 to 0 in negative cycle. The frequency of the wave depends on the speed of incrementing and decrementing. The speed of incrementing and decrementing also depends on delay loop.

The sawtooth wave is generated only by incrementing the values evenly from 0 to 1024 in positive cycle and by directly decrementing 1024 to 0 at the initial negative cycle. Hence the delay code for this wave is only for positive cycle. The negative cycle does not require delay.

The sine wave is generating by using the formula given in equation (2).

A. Equations

$$Frequency = \left(\frac{1}{Ton+Toff}\right) \quad (1)$$

$$Sample\ rate = output\ frequency\ X\ No.of\ Samples \quad (2)$$

$$Sample = \left(\sin\left(n \times \frac{360}{64}\right) \times S\right) + Z \quad (3)$$

Where Ton is the on time period.
Toff is the off time period.
n = (0 to 63)
S is ±127
Z= 127

Sample rate is determining the speed of a sample per second. For example, output frequency is 4MHz and number of samples is 64, then the sample rate is 256Msps (Mega samples per second).
Using “(2)” the sample’s amplitude is calculated “(3)”. For example, n=0, S=+127, Z=127, then Sample = 127. The samples are calculated and it is added in the sine table of the sine loop in main.c. There are about 64 samples.

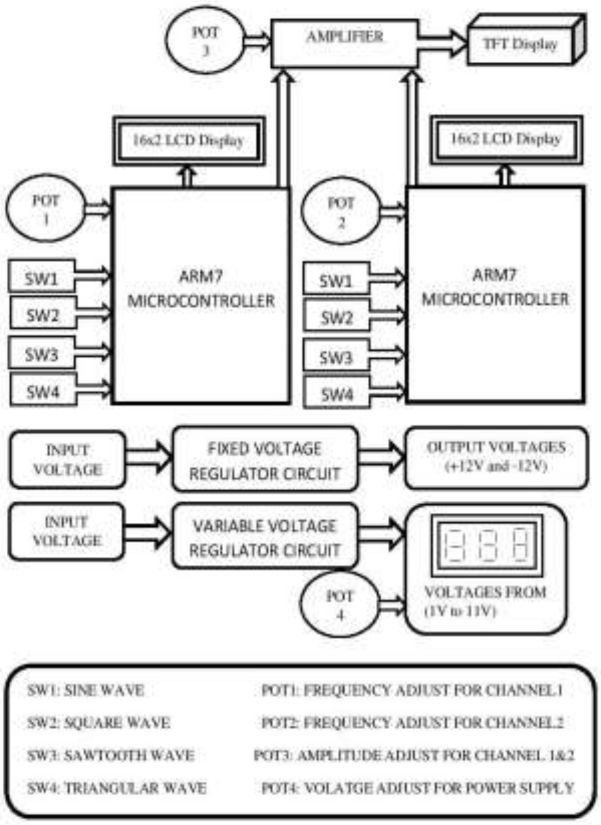

Fig1: Block Diagram

V. RESULT

The features of this module is given in table1. Waveforms that are generated using this module are displayed on DSO138, it is shown in figure3,4,5,and 6. Figure3 shows the generated sine wave. Figure4 shows the generated square wave. Figure5 shows the generated sawtooth wave. Figure6 shows the generated triangle wave. The waveforms are generated individually from both the channels. The frequency of the generated waveforms can be varied using pot1 and pot2. The voltages of the generated waveforms can be varied using Pot3. The supply +12V, -12V and variable voltages care used to conduct experiments.

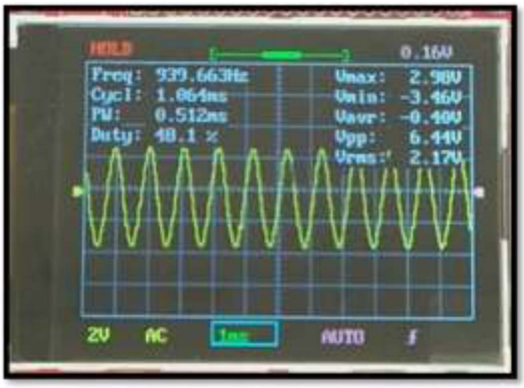

Fig3.Sine wave

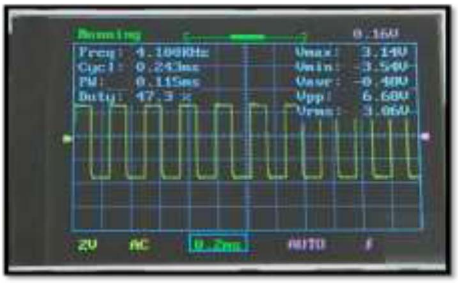

Fig4. Square wave

Fig5.Sawtooth wave

Fig6.Triangle wave

Fig7: Digital function generator with variable power supply.

TABLE I. TECHINICAL FEATURES

Parameters	**Range**
Number of Channels	2 channels
Waveforms	Sine, Square, Sawtooth, Triangle
Frequency	1Hz to 3.6MHz
Amplitude	1V to 5V
Variable voltage	1V to 13V
Fixed voltages	+12V and -12V
USB port	One

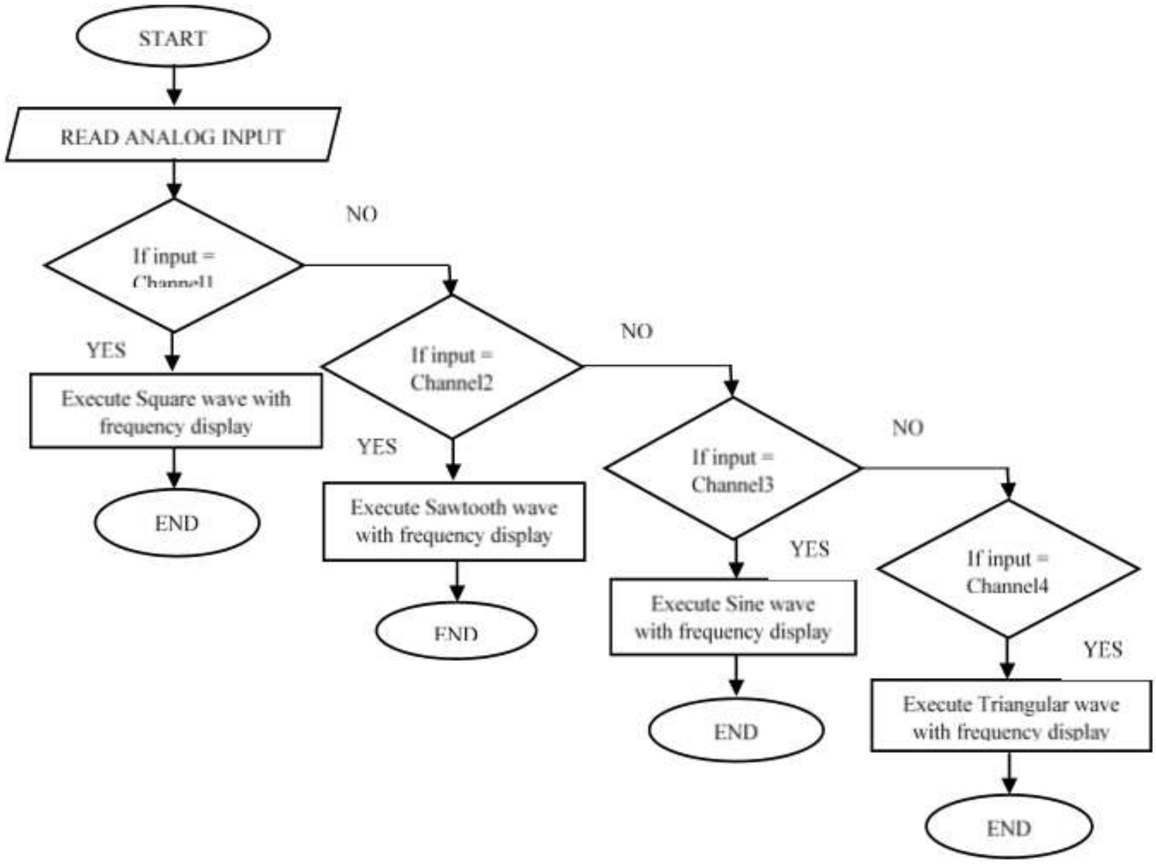

Fig2: Flowchart

CONCLUSION

The above study concludes that hardware of this module can be designed to bring all analog testing device into one module. Hence this reduces the cost of four analog testing devices into one device. It also reduces the cost. Thus this module is specially designed for academic purpose and provides ease of use.

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